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Mechanization of the Potato Crop

NORMAN SMITH

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CULTIVATIONS for potatoes are now completely mechanized, and are intended to produce a deep tilth with very few clods so that harvesting is made less difficult. Those cultivations carried out in spring should be designed to conserve soil moisture. After deep autumn ploughing the first breaking of the furrows in the spring with a tined cultivator probably does little toward breaking down soil aggregates, but merely disturbs the soil and sifts it in such a way that large clods are brought to the surface for breakdown in the next operation.

Soil Moisture Conservation

Rotary cultivators can make a good tilth very quickly after the soil has first been stirred; one slow passage over the ground with such a machine can often produce a finer tilth than is possible after several harrowings. Many farmers in East Anglia are beginning to rely on this method of producing a tilth to help them with soil moisture conservation. Here all the cultivations are carried out in the same direction as the potato rows are to run, and the tined cultivator or heavy harrows and the rotary cultivator are never more than a few rounds ahead of the planter. In this way only a few minutes elapse between the first breaking up of the soil and the actual planting and covering of the seed potatoes. Moisture loss from the turned-up soil is reduced to a minimum. Rotary cultivators have another advantage for potato cultivations. Apart from the quick and efficient clod breaking they do, the number of tractor journeys across the soil to produce a given fineness of tilth is reduced, and fewer new clods are formed under the tractor wheels than would be the case if the cultivations were carried out by traditional methods.

Application of Fertilizers

Fertilizer placement has received much attention. Heavy dressings can cause "scorching" of the growing chits, especially in a dry season, and some means of separating the fertilizer from the newly planted set, while still concentrating it fairly near, is essential. Many planters, designed to work on the flat and draw out their own ridges, place the fertilizer in bands beside the sets, but many growers prefer to draw out the ridges separately. Where this is done the fertilizer can be sown in the furrow bottom, just behind the ridging bodies, in the same operation. With a good, fine tilth and the forward speed of the ridger kept around 3 m.p.h., spill-back of soil from the sides of the ridges covers the fertilizer with a thin layer of soil, protecting the set which will be planted a few minutes later.

To make harvesting easier and less damaging to the potatoes, seed potatoes should be planted with several inches of cultivated soil beneath them so that the share of the harvesting machine does not take in any subsoil clods. Even where a deep tilth allows this, the effect is spoiled by 3-row planters working on previously ridged land. The wheels of the tractor pulling the planter run in the furrow bottom and compact the soil directly in front of two of the three rows of potatoes being planted. A set of tines running behind the tractor wheels, just ahead of the planter, are often used to break up the compaction, but clods large enough and stable enough to cause trouble at harvest will probably be left. Cage wheels on the outside of the tractor wheels can transfer much of the weight of the tractor on to the ridges which are immediately split back and thoroughly broken up by the covering bodies.

Planting Chitted Seed

Special hand-assisted planters are used where chitted seed is planted successfully. On these machines the operators, of whom there must be one for each row mechanism, usually handle around 80–90 sets per minute, although rates of working of over 100 sets per minute have been observed. Fully automatic planters are widely used in the U.S.A. and these machines impale the individual sets or seed pieces on sharp tines. Each row mechanism can deal with up to 450–500 sets per minute. However, such mechanisms are unsuitable for use with chitted seed as their action removes too many chits. One type of automatic planter, available in this country, allows the potatoes to roll into cups on an endless belt which feeds the spacing mechanism. A single operator is employed to supervise three rows and fill any cups which are not already carrying a potato. This machine saves two out of three operators and is reported as dealing quite satisfactorily with chitted seed.

Inter-row Operations

For all inter-row operations such as earthing up and spraying, there are two main points to be noted. First, every precaution should be taken to prevent soil compaction and clod formation; clods on the ridge add to the soil separation problem at harvest. Second, the crop foliage should not be damaged by the passage of tractors along the rows. Some growers find it worthwhile to shield both front and rear wheels of their tractors to avoid running down of foliage. Wider rows reduce the foliage damage problem. In Britain, a change from 28 in. rows to, say, 36 in. with closer plant spacings in the rows might be useful for preserving the potato tops.

After the growing season the foliage must be killed and destroyed to encourage hardening of the tuber skins and leave the field clear for the harvesting operation. A great bulk of haulm must be removed and a combination of chemical and mechanical destruction is often used. Machines with rubber flails and even flail-type forage harvesters have

been used for this task; the air sucked in by the forage harvester tends to draw up vines that have dropped into the furrow bottom.

Machines with horizontally rotating knives are used; one machine of this type has its knives inclined like the blades of a propeller. A considerable up-draught of air is produced by the blades and the drooping vines are lifted to give a very clean cut. Numerous experiments in the U.S.A. have been directed towards producing a machine to pull the haulm out of the ridge. In almost every case, however, a considerable number of potatoes adhere to the stems and are pulled out with them. It has been suggested that a type of potato might be bred which could be harvested by pulling the whole plant out of the soil by its top, but this is only a possibility for the distant future. In the meantime soil and potatoes must be separated in a harvesting machine.

Problems of Harvester Design

In potato harvesting the basic job of separating some 10 or 12 tons of potatoes on every acre, from 350 to 400 tons of soil taken into the harvester, is not easy. Disc shares, developed by the N.I.A.E., go some way to easing the problem since they lift only the soil from the top and centre of the ridge. The shoulders of the ridge are left on the ground because normally no potatoes are found there. However, it is in these shoulders that many of the clods caused by tractor wheels are found.

Once the soil and potatoes pass over the shares of elevator diggers and simple harvesters, the potatoes are separated from the soil by riddling, that is on a basis of size. Loose soil falls back to the ground, potatoes, stones and clods remain on the machine for hand sorting on the basis of appearance. No mechanical means of sorting on appearance is yet available but a number of criteria have been used as a basis for mechanical separation.

In the Maine potato-growing area of the U.S.A., a great deal of trouble was experienced due to the large number of stones in the soil. Harvesters with the last horizontal conveyor sloped to one side at an angle of around 20 degrees have been found to give almost 75 per cent mechanical separation of stones and potatoes. Potatoes and stones are delivered on to the high side of the conveyor, the round potatoes roll to the low side of the conveyor, while the angular stones remain on the high side. For a 1-row harvester only three operators are necessary to give manual assistance with the sorting. A machine embodying a further development of this technique employs an air blast across a flat belt conveyor which carries the potatoes and unwanted stones. The air blast causes the potatoes to roll across the conveyor into the delivery elevator, while the stones, along with any trapped potatoes, are carried on under a rotating bristle brush. This brush flicks the round potatoes back into the air blast while the heavy stones deflect the bristles and pass beneath the brush. Two operators are usually sufficient to cope with any hand separation necessary on this machine.

Some British-made potato harvesters now sort clods from potatoes by taking advantage of differences in shape. There is not as much difference between potatoes and glaciated stones but if a mixture of clods and potatoes are placed on an upward-moving surface, the slight angularities on the surface of the clods prevent them from rolling down with the potatoes.

Potatoes, with a specific gravity varying from 0·95 to 1·10, are much less dense than clods and stones whose specific gravity is seldom below 1·8. One harvester made in Britain some years ago floated the potatoes away from clods and stones through a soil-in-water suspension and made a first-class job of separation but failed because the keeping quality of the potatoes was spoiled. Attempts have been made to float potatoes out of mixtures with stones and clods in a vertical airstream to get over the keeping quality problem occurring with water flotation. Experiments at the N.I.A.E. Scottish Station have been only partly successful because the surface-to-weight ratios of bodies are not the same in all directions except for near-spherical objects. An air velocity of 115 ft per second was found to be sufficient to lift all potatoes used in the tests, but 58 per cent of some stones collected at random from nearby potato clamps were also lifted.

A potato harvester produced in the state of Maine uses the flotation method of separating stones and potatoes and works quite well. The airstream passing through a chain conveyor carrying the stones and potatoes is set at approximately 30 degrees to the horizontal. Flat stones, which tend to be picked up too readily by a vertical airstream, are seldom lifted in this machine because they are not usually lying facing the airstream. Where they are picked up they quickly slide downwards back on to the conveyor. Very little hand assistance is required by this harvester and 2-row models were produced for the 1959 harvest.

Avoiding Tuber Damage

Avoiding tuber damage is vitally important in potato harvesting. Seedbed preparations, planting, and inter-row work can have been perfectly carried out so that no clods are present, but if the harvesting operation is carried out carelessly the incidence of mechanical damage will be very high.

The minimum of agitation should be used. Agitation in a digger or harvester may break clods but it damages the potatoes, and the forward speed should be kept as low as possible. In one experiment, where the digger was adjusted to give a good carry over of soil, digging at a speed of only 2 m.p.h. resulted in over 70 per cent of the total number of tubers showing some kind of mechanical injury.

Handling of the newly-harvested tubers should again be as gentle as is possible. The height of drop from the delivery elevators of some British harvesters approaches 5 ft, in spite of the fact that considerable publicity has been given to experiments which show that a large potato is damaged by a drop of as little as 6 in. on to a board floor, and by a

drop of as little as 2 ft, even on to other potatoes. American manufacturers and potato growers are very conscious of the damage problem, and all their harvesters have an easily lowered delivery elevator which is used to place, rather than drop, the tubers into the transport vehicle.

Tipping trailer loads of potatoes into elevator hoppers gives turn-round times at the store of as little as 5 minutes, but subjects the potatoes to some very rough handling. Conveyor-bottomed hopper bodies are now becoming available in this country and handle the potatoes very gently, though they require a longer time to unload a given weight of potatoes.

The practice of handling hand-picked potatoes in 5 cwt stillage boxes has become popular over the last two or three years. Existing hydraulically-operated tractor loaders, with only minor modifications, are used, and most of the hand work is taken out of field loading hand-picked crops. For short hauls the tractor can carry two or three stillages direct by means of its hydraulic system; for longer hauls the stillages are tipped into trailers in the field. Tipping tends to be a little rough on the potatoes when done hurriedly in the field and it is likely that in using boxes merely as transport containers the best use of them has not yet been made. Picking or harvesting directly into boxes in which the potatoes will be stored has many advantages. Handling damage is reduced as the tubers do not move relative to each other, or their container, until they are tipped on to the end of the grading line just prior to sale. Storing in separate boxes also puts a limit on the spread of disease arising from any one focus. Five-cwt boxes would be too expensive a means of storage, but the use of 15- or 20-cwt boxes might be feasible, though such large boxes could not be handled by present stillage handling equipment on tractors.

Handling in the Store

Mechanization of removing potatoes from the store is still in its infancy on most farms. The potato fork, with all the damage it causes, remains the sole means of getting the potatoes from the stack to the sorter. Water fluming is possible for indoor stores where the crop is to be washed before sale. For potatoes which are to be sold unwashed the main ventilating duct can be used to hold a belt conveyor working under the stack. By removing covering boards one by one, potatoes can be allowed to roll off the face of the stack on to the conveyor and be carried out for grading. Such an arrangement saves a man and results in more gentle handling of the potatoes. For a store with one main air duct running centrally up its length, many potatoes will still need to be loaded manually on to the sorter. The provision of, say, three parallel ducts running up the length of the store would greatly reduce the quantity of potatoes which would need to be hand forked, and would allow almost as much cheap mechanical unloading as is possible in some of the North American potato stores which are divided into narrow

bins with a conveyor trench beneath each bin. This is just one more situation in which a more gentle handling of potatoes might accompany a reduction in operating costs.

Methods of Plant Breeding

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PLANT BREEDING consists of finding genetically superior plants which can be multiplied for release as new varieties. To be able to select superior plants, the breeder must either find or make populations with genetic diversity. To recognize the superior plants and stocks bred from them, he must have efficient tests for yield, quality, field characters, and disease resistance, and to be able to multiply the plants for release as a new variety, which will have the characters of its selected parents, he must understand the mode of reproduction of the species being handled.

The breeding techniques which can be used are determined to a large extent by the mode of reproduction of the crop species, whether it is a self- or cross-pollinator or vegetatively reproduced. It is technically much easier to breed self-pollinating species such as the cereals, than cross-pollinating plants such as the grasses, clovers, sugar beet, and kales; and species such as the field bean (*Vicia faba*) and the swede (*Brassica napus*), in which there is a balance between cross- and self-pollination, present a particularly difficult task to the breeder. The only field crop grown in Great Britain, which is normally reproduced by vegetative propagation, is the potato. Such a crop is easy to handle in that every new seedling, however heterozygous, will come true to type so long as it is reproduced vegetatively.

Self Pollinators

THE PRODUCTION OF DIVERSITY.

A variety of self-pollinated crop consists of plants which are genetically homogeneous and which breed true. Hence, except for very rare mutations, there is no scope for any improvement by selection within single varieties, although occasional re-selection may be necessary to eliminate undesirable types or admixtures. Occasionally a useful mutation can, however, be found. One example is 'Earl' barley which arose as a mutant in 'Spratt Archer.'

To produce diversity in self-pollinated crops it is necessary to hybridize two or more varieties. In many programmes two varieties only are hybridized, but in certain cases multiple crosses may be used. Thus, if four parents (a, b, c, and d) were used, two single crosses of ($a \times b$)

and $(c \times d)$ would be made, and the F_1 plants would be crossed to give $[(a \times b) \times (c \times d)]$. This should in many cases result in more diversity in the F_2 than would be shown by single crosses.

THE PEDIGREE METHOD OF SELECTION

A standard selection method in breeding self-pollinated crops, which has produced many of the new cereal varieties developed during the past fifty years, is known as the pedigree method. In this method the best plants are selected in the F_2 and subsequent generations of either single or multiple crosses, the produce of each selected plant being grown separately in the following generation. Because they are self-pollinated, this repeated single plant selection results in the different selections being more or less true breeding by about the F_6 generation. Single plant selection ceases at this stage, and the different selections are bulked up so that observation plots and small scale trials can be grown. It is obvious that successful breeding by the pedigree method of selection depends very largely upon the skill of the breeder in recognizing the superior plants in each generation.

THE BULK METHOD

The bulk method differs from the pedigree method in that the material from the F_2 to about the F_6 generation is handled as a bulk, and single plant selection is not made until about the F_6 generation, when most plants will be breeding more or less true. An advantage over the pedigree method is a big saving in labour while the material is being handled as a bulk, and this may make it possible for a breeder to handle more crosses. On the other hand, breeding by the bulk method takes longer as pedigree selection has to be made after the F_6. Selecting the best F_6 plants requires the same skill from the breeder as is used each year in the pedigree method.

MODIFIED PEDIGREE METHODS

In both the pedigree and the bulk method yield trials are not made until bulks from the selected F_6 plants are available in about the F_8 generation. This means that the breeder must have confidence in his ability to recognize the superior plants by eye-judgement. Methods in which earlier yield trials are made include the "F_2 progeny method of selection" and the "pedigree trial method of selection" described by Lupton and Whitehouse.[1] In the F_2 progeny method of selection, the progenies of selected F_2 plants are grown in yield trials without further selection during F_4, F_5 and F_6. Single plant selections are then made after the F_6 from those progenies which appear most promising. In the pedigree trial method of selection, normal pedigree selection is carried out in F_2 and F_3. In the F_4 generation, single plants are selected from the better progenies for continued pedigree selection, and within each of these progenies the remaining plants are bulked to give seed for

a yield trial in the following year. This process is repeated in F_5 and F_6, the seed for trial being obtained in each case from the progeny rows and not from the preceding trial. Since the purpose of both methods is to enable yield trials to be grown in early generations when large numbers of selections are being handled, it is necessary to employ trial layouts such as cubic lattices and lattice squares in which large numbers of selections can be compared.

THE BACKCROSS METHOD

The backcross method can be used for breeding all species, whatever their mode of reproduction. It is particularly appropriate for breeding programmes in which it is desired to transfer a character such as disease-resistance from one variety to another, especially when the character is determined by only one or two genes. When used with a self-pollinating species and when the character to be transferred is due to dominant genes, the procedure is as follows. The F_1 hybrid is back-crossed to the variety (the recurrent parent) to which the character has to be transferred. The first backcross plants are selected for the desired character and again backcrossed to the recurrent parent. This process is continued for up to six generations, selection for the desired character being made in each generation. The plants of the last backcross generation are allowed to self and pedigree selection is made of their progeny to obtain plants breeding true for the added character. If the character to be added is due to recessive genes, the backcross method is much more tedious as selfing has to be made after each backcross to recover the desired character. Backcrossing programmes are being carried out at the Plant Breeding Institute, Cambridge, for the breeding of powdery mildew-resistant varieties of wheat, barley and oats.[2]

CHOICE OF PARENTS

With the considerable number of new varieties which have been introduced in recent years, particularly in the cereals, it is often difficult for the breeder to decide which are the best crosses to make. One possible help in this difficulty is the technique of diallel-cross analysis. The method consists of crossing a number of varieties in all possible combinations and carrying out a particular type of statistical analysis of the performance of the hybrids to obtain indications of the value of each cross and the type of inheritance involved. Details of one such analysis have been given by Whitehouse, Thompson and Ribeiro.[3]

Cross Pollinators

OBTAINING HOMOGENEITY

In a cross-pollinated species the problem for the breeder is usually not in creating genetic diversity, but in restricting it. Selected superior plants will usually be highly heteroxygous and the progeny from such plants may contain a similar proportion of good, medium, and poor

individuals as occurred in the population from which the selection was made. Forced inbreeding of the selected plants to obtain greater uniformity results, in most cases, in a considerable loss of vigour.

When plants of the species being bred, as for example grasses and clovers, can be maintained and increased by vegetative propagation, the breeding of relatively homogeneous, vigorous, and stable varieties has been achieved by testing the possible parents of a potential new variety for their ability to produce offspring which are closely similar to the parent material. This is done by either selfing the possible parents or crossing them in pairs. Possible parents which produce too high a proportion of undesired types are discarded, and the new variety, sometimes called a synthetic, is based only on the selected plants which give relatively homogeneous progenies of the desired type. This is the method which has been used largely in the breeding of the Aberystwyth varieties of grasses and clovers.

THE POLYCROSS TEST

In the polycross test the provisionally selected parents for the proposed new variety are planted in a plot in such a way that they will pollinate each other uniformly. The seed from each selected plant is then harvested and kept separate. When grown on, this seed gives plants which should enable the breeder to evaluate the ability of the provisionally selected parents to produce relatively uniform progenies of the desired type. An advantage of the polycross test is that it is similar in principle to the process occurring later in the multiplication of the parents to produce the seed of the new variety.

SINGLE- AND DOUBLE-CROSS HYBRID SEED

In many ways the most satisfactory method of breeding cross-pollinated species is the production of single- or double-cross hybrid seed. Hybrid seed has, of course, been widely used for sweet corn and maize in North America. The method consists of inbreeding to obtain uniform inbred lines of the desired type which are then tested for their ability to produce good hybrids. The inbred lines show great loss of vigour, but vigour is fully restored in the hybrids. Because of the high cost of single-cross seed, double-cross seed is used for maize. Four inbred lines are necessary, and the seed distributed for growing the farmers' crops is of the type $[(a \times b) \times (c \times d)]$. The production of large amounts of double-cross maize seed at an economic price is possible because maize has its male and female flowers on separate inflorescences and because the male inflorescences can be easily removed.

THE USE OF MALE STERILITY OR SELF-INCOMPATIBILITY

Even when a species does not have separate male and female inflorescences, it may be possible sometimes to produce large quantities of single- or double-cross seed. One method is to make use of male-sterile plants. Various techniques are necessary for this, depending on

the genetic type of male sterility used. Male sterility is being used at the National Vegetable Research Station in producing hybrid seed of brussels sprouts and onions,[4] and at the Plant Breeding Institute, Cambridge, for field beans. It may also be very useful with sugar beet (see below).

In self-incompatible species, inbred lines homozygous for the incompatibility (S) genes can be obtained by inbreeding, using devices such as bud pollination which overcome the incompatibility. Thus four lines of the constitutions, S_1S_1, S_2S_2, S_3S_3, and S_4 S_4 can be obtained and these can be allowed to pollinate in pairs to give S_1S_2 and S_3S_4 seed. Plants grown from such seed will set no seed by selfing and can be used to produce double-cross seed for growing the farmers' crop. This method is being developed at Cambridge for marrowstem kale, see Thompson.[5]

Induced Polyploidy

The possible uses of artifically produced polyploids in plant breeding have been discussed by Bell[6] in an earlier number of this *Review*. As he points out, there are two types of polyploids: autopolyploids produced by an increase in chromosome number in a single species, and allopolyploids produced by doubling the chromosome number of either interspecific or intergeneric hybrids.

One successful use of induced autopolyploidy in producing new varieties of field crops is found in sugar beet. The "polyploid" seed sold to the farmer is a mixture of diploids, triploids and tetraploids obtained by allowing natural pollination to take place between diploids and tetraploids. The triploids, which form between 40 and 50 per cent of the mixture, are the highest yielders, and part at least of their vigour may be due to their hybridity rather than their ploidy. Recently, by using a diploid male-sterile type with a tetraploid pollinator and by cutting out the male pollinator before harvest, it has been possible to produce sugar beet seed which is about 85 per cent triploid (the 15 per cent of non-triploids occur because the diploid male-sterile type does not breed absolutely true). This method of seed production is expensive, but it is claimed that the increased sugar production from this type of beet far outweighs the extra cost of the seed.[7]

Other successful uses of induced polyploidy have been tetraploid varieties of red and alsike clovers. So far, however, in spite of considerable work, particularly with wheat-rye hybrids, there does not appear to have been any successful use of artificially-produced allopolyploids in the breeding of field-crop plants.

Interspecific and Intergeneric Hybridization

As well as their possible use in producing allopolyploids, interspecific and intergeneric crosses can be used for other types of breeding, particularly when it is desired to introduce disease-resistance into a cultivated species from its wild relatives or primitive ancestors. This is

usually done by a backcrossing programme, but there are often difficulties due to sterility or to the failure of the chromosomes of the two species to pair and exchange genes. It is easier to use such crosses with vegetatively-reproduced crops, and two potato varieties, 'Pentland Ace' and 'Ulster Torch', which are highly resistant in the foliage to some races of blight, were bred from crosses involving the wild Mexican potato, *Solanum demissum.*

Alien Chromosome Addition and Substitution

Although artificial allopolyploids, which contain two whole chromosome sets from each of two species, do not appear so far to be promising as new varieties, it is possible that alien chromosome addition and substitution lines may be useful for breeding new varieties in the future. Alien chromosome addition lines contain two whole chromosome sets from one species and a single pair of chromosomes from another species. In alien chromosome substitution lines, a single pair of chromosomes of one species is replaced by a pair from another species. This type of breeding is being intensively studied at Cambridge with wheat.[2] Another possibility is afforded by plants in which only a small chromosome segment from one species has been added to the chromosome complement of the other species. Such plants can be produced by X-ray treatment of chromosome addition lines.

Induced Mutations

It has been known for many years that X-rays produce mutations, but it is only relatively recently that it has been suggested that X-rays and other mutagenic treatments may be useful in plant breeding. At the present time many breeders are doubtful of the value of induced mutations, but they would obviously be of great value if it were possible to change single characters only in varieties of proved value.

Aids to Selection

In this article only the techniques of breeding have been considered. The invaluable aids which plant breeders have received from the cognate sciences must however be mentioned briefly. Of particular importance to the breeder have been studies by pathologists of disease-resistance, methods of testing for resistance, and variation in the pathogens. Small-scale tests for quality developed by chemists are similarly of very great importance. Plant physiological work has been of help, for example, in showing that in many crops it is possible to raise more than one generation a year and thus save much time in the early stages of a breeding programme. Finally, it is obvious that breeders are greatly indebted to statisticians for the invention of trial layouts with which reliable tests of selections and possible new varieties can be made.

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Onion White Rot

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WHITE ROT is a familiar and serious soil-borne disease of both salad and bulb onions in this country. In salad crops it may occur amongst young plants in October and November, following late summer sowing, and again in the spring; with bulb crops sown in early spring it is usually found in late spring and summer. The fungus persists in soil for an indefinite period, and it has been generally and naturally assumed that this survival is in the form of sclerotia which are produced in large numbers at the base of infected plants. The work of Booer[1,2] and of Croxall, Sidwell and Jenkins[3] has provided a reasonable, if rather expensive, method of control. However, outbreaks of the disease were recorded during the war-time expansion of onion growing, for which no satisfactory explanation could be found. Thus attention has been focussed on the need for further work on the biology of the fungus.

Host Range Experiments

Although recent work[4] has extended the known host range of *S. cepivorum* within the genus *Allium*, there is no evidence that it can attack other plants. Of the cultivated *Allium* species it has been recorded on onion (*A. cepa*), leek (*A. porrum*), shallot (*A. ascalonicum*), garlic (*A. sativum*), welsh onion (*A. fistulosum*), and it has proved pathogenic to chives (*A. schoenoprasum*). In addition it occurs on wild onion (*A. canadense*) and on crow garlic (*A. vineale*), weed hosts in the U.S.A.[5] and England,[6] respectively. It has also proved pathogenic to ramsons (*A. ursinum*). The following plants, included in Coley-Smith's host range experiments,[4] were unaffected: single varieties of cabbage, Brussels sprout, beetroot, carrot, barley, red and white clover; and a

* Formerly at the University of Birmingham.

series of common wild plants, *Agrostis tenuis*, *Lolium perenne*, *Dactylis glomerata*, *Festuca rubra*, *Agropyron repens*, *Senecio jacobaea*, *S. vulgaris*, *Taraxacum officinale* and *Endymion non-scripta*. Careful search by Croxall, Sidwell and Jenkins[3] failed to disclose any infection of weeds in beds of infected onions.

Conditions for Development of the Disease

Although a crop may be completely destroyed by white rot, it does not follow that a succeeding one will be attacked, for the disease requires particular conditions for its development. In the U.S.A. Walker[7] showed that white rot is very active over the temperature range 10–20°C and at the comparatively low soil water-holding capacity of 40 per cent, and he was able to correlate these results with the distribution of the disease in that country. Croxall, Sidwell and Jenkins[3] also observed the association of outbreaks of the disease with cool spells and dry conditions in Worcestershire. The effect of dry soil conditions, however, would seem to be not only to encourage the fungus to attack but also to promote the appearance of symptoms amongst plants already infected, for in the field quite badly diseased plants may not show leaf symptoms in wet weather but soon do so when the soil dries out. Observations on the influence of pH on the disease are conflicting. Although reduction in the severity of the disease has been reported as a result of liming, there is no evidence that soil pH plays a significant role in the etiology of the disease in this country, and in fact Croxall, Sidwell and Jenkins[3] observed that white rot occurs equally in acid and alkaline soil and on all soil types on which the crop is grown in the Vale of Evesham, ranging from light, sandy glacial drifts to lias clays.

Was Contaminated Seed a Source of Infection?

Where crops are grown from transplanted seedlings or sets, the danger of using infected planting material is well recognized and infection has often been traced to this source. In crops raised from seed it has proved more difficult to discover the origin of the disease. Following the extension of onion cultivation in this country during World War II, severe outbreaks of white rot, some involving losses of over 90 per cent of the crop, were reported on a number of occasions on land either carrying its first onion crop or on which onions had not been grown for many years. Apart from the interesting question of how the fungus got there, the repeated isolation of *S. cepivorum* from the top of the flower stalk and the inflorescence of leeks kept for seed purposes, and the presence of this infected material amongst rubbed out seed[6] suggested that seed contamination might be an important source of infection for such outbreaks. However, Croxall, Sidwell and Jenkins[3] were unable to provide any evidence in support of this idea. They examined nearly 100 samples of onion seed without finding the fungus, and thought it unlikely that sufficient infected seed, or sclerotia, could be present in a

seed sample to result in almost complete loss of crop. Moreover, the pattern of infection in certain of the fields which they examined did not fit with what might have been expected from the use of infected or contaminated seed and, in some instances, the same stock of seed gave rise to an infected crop on one piece of land and to a healthy one on an adjacent plot. A possible explanation could be that inoculum was introduced on farm implements and machinery (though it is difficult to understand how sufficient inoculum to cause an epidemic could be so introduced), or, more likely, that it was present in soil around the roots of previous crops, e.g., sprouts, transplanted from contaminated land, but evidence for such introduction is lacking. Some outbreaks on new land, or on land free from onions for many years, may also be due to the presence of *A. vineale* but this could not be a general explanation because the weed is confined (at least in the Evesham area) to heavy clay soils.

Another Possible Source of Infection Disproved

Another possibility was that *S. cepivorum* was a member of the general soil microflora, a soil inhabitant, persisting as a saprophyte until the presence of its host gave rein to its parasitic ability. This has been disproved by Scott[8] who found that the mycelium has almost no saprophytic ability. Two factors in particular would discourage the growth of *S. cepivorum* in soil. Firstly, soil appears to lack the nutrients that the fungus requires, and secondly, members of the soil microflora are antagonistic towards it. Temporary control of the disease has been obtained by making use of the antagonism of *Penicillium nigricans* towards *S. cepivorum*,[9] but whether biological control could be used as a practical method of controlling the disease in the field is not known.

S. cepivorum can only grow through soil from a food base of infected tissue, on which it is completely dependent, and then only for a limited distance and time. In closely-spaced plants the fungus can, however, spread fairly rapidly through root contact, but where this is prevented no spread occurs even though adjacent plants are almost touching each other.[10]

Sclerotium Structure and Population Assessment

Whatever the method of introduction of *S. cepivorum* to the soil, infection is quickly followed by production of sclerotia in large numbers. Most sclerotia lie within the range of 0·2–0·5 mm in diameter and by washing soil through two sieves of mesh size 0·5 and 0·2 mm, respectively, the sclerotium population of soil can readily be assessed. Samples taken from plum orchard sites in the Evesham area in 1953 were free from sclerotia, but on two of these sites part of the orchard had recently been grubbed and on the cleared land onions had been attacked by white rot. Here the sclerotium population was several thousands per square yard, sampled to a depth of 9 in.

Sclerotia have proved to be remarkably resistant structures.[11, 4] In the laboratory they were unaffected by two years' dry storage and were only destroyed by the anaerobic conditions of waterlogged soil which favoured bacterial decay, especially in the presence of additional organic matter and at high temperature (25–30°C). In undisturbed soil, out of doors, there was no significant reduction in numbers or viability of sclerotia at depths of 3, 6 and 9 in. after four years, and it is possible that they can survive for much longer periods judging from field records. Further fields tests showed that survival of sclerotia was unaffected by soil pH and nutrient status but in pot experiments there was some evidence that organic amendments could bring about a large drop in sclerotium population. This effect could not be produced consistently, however, and requires further investigation.

To function as perennating organs sclerotia must be capable not only of survival but also of germinating and causing infection. After being placed in soil, sclerotia from sand/cornmeal cultures pass through a period of dormancy lasting between one and two months. This dormancy appears to be associated with the sclerotium rind, for if it is damaged by gentle abrasion in a mortar, exposing areas of the medulla, germination takes place. After germination, sclerotia become hollow shells and finally rot completely. Although sclerotia are in contact with abrasive particles in soil in the field, germination as a result of abrasion is unlikely from normal cultivation operations, for there was no reduction in sclerotium numbers in experiments in which soil containing sclerotia was disturbed frequently by vigorous trowelling at weekly intervals.

Stimulation of Sclerotium Germination

In the field it is clear that the host plants themselves provide the stimulus to germination, for example, where onions are planted in soil containing sclerotia, the latter respond by vigorous germination leading to infection, whereas in the absence of a host plant there is virtually no germination.[12, 13] This effect has been shown not only with growing plants but also with water extracts added to soil containing sclerotia. The stimulant is secreted in greatest concentration from root tips; and root injury promotes its release as shown by an increase in speed and final level of sclerotium germination. The stimulant, diffusing outwards from the root, exerts its effect on any sclerotia which lie in the immediate vicinity; there is frequently a positive orientation of the mycelial plug, formed during germination, towards the root providing the stimulant. The stimulant has not yet been isolated and identified, but it is evidently peculiar to *Allium* species, since no effect has been produced using plants outside this genus, such as beetroot, carrot, barley, cabbage, brussels sprout, garlic mustard (or their extracts). One further point emerging from this study is that the conditions for this host-stimulated germination of sclerotia are not the same as those for disease development, for sclerotia germinated over a wide range of soil pH levels and water

contents, maximum germination occurring above pH 7·0 and at 90 per cent water-holding capacity.

The Need for further Research

The demonstration of stimulation of sclerotium germination is another illustration of a common biological phenomenon which includes the well known stimulation to hatching of eggs of the potato root eelworm (*Heterodera rostochiensis*) by potato root exudates. Whether the phenomenon can be put to practical use—to stimulate sclerotium germination in the soil in the absence of the host—must await isolation and test of the substance responsible.

In conclusion, since current methods of control by calomel—applied either to the drill or to the seed—give only very local distribution of the fungicide, one must presume, when considering this new information on the biology of the fungus, either that the effect of the fungicide extends much further than its actual location (otherwise roots could become infected some distance away, invasion travelling thence to the bulb) or that only those sclerotia in the surface layer of soil germinate, as occurs in some other sclerotium-forming fungi, e.g., the clover rot fungus *Sclerotinia trifoliorum*. It is hoped that future investigation will resolve these and other questions arising from the work that we have discussed.

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Trends in Commercial Flower Production Under Glass

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NO DOUBT due to a reduction in the profitability of the tomato crop, more interest is being shown in flower crops grown under glass. It is fairly certain that specialist growers have been obtaining useful returns and that the comparatively high costs of flower crop production are fully justified. It seems equally certain that there is an upper limit to the demand for flowers, and that if supply exceeds demand with such perishable produce, the returns from the crop will be sharply reduced. The economics of tomato growing are of vital importance to the glasshouse industry as a whole, and to flower growers in particular, because if the return from the tomato crop is reasonable, there will be less inducement for growers to change from a tomato to a flower crop, and therefore less likelihood of the market being over-supplied with flowers.

In flower production there has always been a tendency to specialize, e.g., in glasshouse roses and carnations, and this continues to an even greater degree. Production on such lines should achieve a higher standard of efficiency, and it is unusual to find these crops grown so well where they are combined with numerous other crops. The need for efficiency in production is becoming increasingly important; costs of production have been going up steadily, but flower prices have been more or less the same for the past five years. With the margin of profit reduced, it is only by increasing the annual output per sq yd. that the position can be restored.

Propagation Units

While growers have always relied on nurserymen to provide a proportion of their requirements in cuttings—rooted or unrooted—there has been a remarkable development in this field during recent years. A few firms have specialized in the propagation of chrysanthemums and carnations, and the demand for rooted cuttings has increased tremendously. This is a desirable trend from the grower's point of view since buying in cuttings saves labour in propagating on the nursery, and has the effect of increasing the potential output from the same area of glass. It does however put a heavy responsibility on the specialist propagators to maintain a very high standard, as any neglect or carelessness on their part could result in the widespread distribution of pests or diseases.

Carnations

Following wartime restrictions, which reduced the area to a few acres, the acreage devoted to the crop increased very rapidly up to 1952. This expansion meant a rapid multiplication of plants and perhaps less careful selection of stock plants and cuttings, and the general health of carnations left much to be desired. Since 1952, the annual rate of increase has been steady at 5–10 acres per year and the total in July 1959 was approximately 202 acres.

The need for healthier stock has resulted in much interest in the culturing of cuttings. This technique involves testing of cuttings before rooting for the presence of wilt diseases, of which Verticillium cinerescens (syn. *Phialophora cinerescens*) is the most devastating. Testing can be, and is, carried out after instruction by quite a number of progressive growers. If properly done, the method is almost a guarantee that none of the diseases listed will be carried over in the stock, and if plants grown from such stock are planted in clean soil the risk of these diseases appearing in a crop is very much reduced.

A further development in the improvement of stock may lie in the use of heat to eliminate some of the virus diseases present in nearly all carnations. Young plants are grown for 4 weeks at a constant temperature of 37°C. in a "hot box" or chamber heated by electricity, with the air circulation controlled by fans. The plants are much weakened as a result of this treatment. Very small, almost microscopic portions of the tip of a shoot are taken and rooted under very artificial conditions on a agar medium. Research on this technique is in progress, for the task of developing roots on such minute portions of plant material is very difficult, and the percentage of success in rooting is at present small. If cuttings from heat-treated plants show the expected increase in vigour and the technique can be developed on a practical basis, productivity may be substantially improved.

The production of clean stock means that on old carnation nurseries, where disease is almost certain to be present in the soil, the crop must be grown in beds isolated from the floor of the house. This trend has been noticeable for some years. On the other hand, if clean stock and disease-free soil are available, many successive crops can be planted on the floor of the house without much risk of their becoming infected, and the high cost of constructing special beds will have been avoided.

In recent years, there has been a tendency to plant more closely in beds, on the assumption that a higher plant population would mean more flowers per sq. ft—at least in the first cropping year. Experiments now in progress have not so far confirmed that assumption, and as wider planting means a smaller outlay on plants, it would seem that the trend may be back to more normal spacings.

The introduction of semi-automatic systems of watering is on the increase. This is partly an attempt to counter high labour cost by mechanizing the work, but sometimes its use can also be justified by

improved distribution and adequate watering during summer and in rush periods on the nursery.

Chrysanthemums

As with carnations, the importance of healthy stock is fully realized. Heat therapy can be used to eliminate some of the virus diseases which affect chrysanthemums. On a small scale, this is carrried out in a similar chamber to that described for the treatment of carnations. On a commercial scale, additional pipes or other heating elements are installed in a greenhouse in sufficient quantity to maintain the desired temperature of 37°C. It is not possible to obtain the very precise "hotbox" control in a glasshouse, but stock treated in this way also shows remarkable improvement in vigour.

Stools or stock plants are grown under the conditions described for about three weeks. The tips of the shoots are removed and rooted in the usual way. The effect of devernalizing by heat has caused some rosetting in early flowering varieties, but it seems likely that an appreciation of this risk will ensure that steps are taken to prevent it happening. There seems little doubt that most specialist producers will use heat to clean up their stocks, but there is a possible danger that treatment, if not quite correctly applied, may speed up the evolution of heat-resistant strains of the different viruses.

The total acreage of chrysanthemums grown in any one year is probably higher now than it has ever been. There have been a number of changes in production techniques during the last ten years, and in every case it is probable that the change has resulted in increased production.

The well-established practice of planting late-rooted cuttings direct in the glasshouse following a crop of early tomatoes, climbing French beans etc., is a case in point. The plants are very frequently bought in for planting on the date specified by the grower and an autumn crop is soon under way with the minimum of trouble. This trend has undoubtedly been encouraged because an early tomato crop is more profitable than one grown through to early October.

Year-round production is developing steadily although the heavy overheads will probably prevent any rapid increase in acreage. The area of glasshouses occupied at the present time is probably 40 acres, and as each acre carries three crops per annum, the total contribution to the cut flower market is considerable. Apart from flowers cut in January and February, the quality produced is first-class and spray varieties are especially appreciated by the retail florist and the public. There can be little doubt that the present trend towards an increased area will continue, but this method of cultivation is expected to remain in the hands of specialist growers.

While the above remarks are intended to refer to cut-flower production, the interest in year-round production of chrysanthemums as pot

plants is also increasing. Well-grown specimens are extremely effective, last well under house conditions, and are good value for money.

The cultivation of English early-flowering varieties under glass, with or without some artificial heat, has been revived during recent years, and the present tendency is to increase the area grown in this way. The crop can be cleared in time to plant mid-season and late varieties of chrysanthemums and forms part of a flower sequence under glass. The effect is to lengthen the season over which the English early-flowering varieties are available and the development of this trend will depend on how this crop withstands competition from year-round production.

Freesias

The acreage of freesias has been going up steadily since the introduction of the coloured hybrids. They are popular with the buying public as they are distinctive, choice, and reasonably priced. Though the demand fluctuates during a season and there are occasional periods of over-supply, the returns would still seem to justify the costs involved.

Using the present methods of cultivation, flowers from the earliest crop grown from seed should be ready for market from early October. Later sowings in containers or in favoured districts in the open, to be covered with a mobile house, maintain a succession which is completed in April with the flowers cut from plants grown from corms. The best returns per bunch are usually obtained in the October–December period and the interest of growers lies in the possibility of getting more flowers at that time. Experiments suggest that shading the plants during the summer months can help and when optimum conditions are finally proved, this will probably become standard practice.

Another method of obtaining flowers in this period and also during the summer months is by making use of specially prepared corms. These are kept at 63°F from time of lifting until the end of December. During this time they make no leaf growth but form a new corm on top of the old one. These corms are then subjected to the normal heat treatment—13 weeks at 83°F and 2–4 weeks at 55°F before planting at the end of April or early May. They are in flower from August onwards. Since the cost of preparing the corms is quite high, continuing interest will naturally depend on the financial success of the method.

Poinsettias

This plant is extremely popular, either as a pot plant or as a cut flower, for Christmas sale in the U.S.A. It has been grown to a limited extent in this country for many years but is now receiving more attention. The brightly coloured spathes are very attractive and make a lively show in the short days of winter.

The plants respond to lighting and shading, and the crop can be timed in much the same way as chrysanthemums. This is important, as the returns can be doubled by getting the crop just right for the Christmas market.

Special care must be taken in packing cut flowers and plants in pots. Transport from nursery to market and to the customer presents some difficulty as the plants are easily damaged by low temperatures.

It is not expected that there will be any substantial development in their cultivation, and, as in other cases, they will probably remain in the hands of specialists.

Conclusion

Although the area of flower crops and pot plants under glass is increasing, and old favourites retain their position, profits will depend very largely on how efficiently they are produced. If over-production occurs, as it might easily, then the inefficient producer will be forced out of business.

Silage Fermentation and its Control

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SUCCESSFUL silage feeding programmes require a well-made product of high nutritive value. The object of this review is to consider what is meant by "well-made silage", in terms of the mechanism of silage fermentation and its control. The aim in silage-making is to achieve, via the metabolic agencies of bacteria on the crop surface acting upon readily fermentable carbohydrate, a rapid production of lactic acid in sufficient concentration to inhibit undesirable microbial activity, so achieving preservation. In addition, dry matter losses caused by fermentation should be reduced to as low a level as possible. Barnett[4] summarized the main changes into the following phases:

Phase 1. Continued respiration of the cells of the cut plant producing carbon dioxide and water, and a flow of water from the crop, because of respiration and mechanical compression.

Phase 2. The production of acetic acid in small amounts by organisms of the coliform group.

Phase 3. (This occurs rapidly following phase 2.) Production of lactic acid by lactobacilli and streptococci in the presence of adequate suitable carbohydrate.

Phase 4. Lactic acid production passes its peak, and the concentration remains constant at about 1·5 per cent of the fresh material.

These four phases are usually completed within 3 weeks. If conditions within the silo are not satisfactory and insufficient lactic acid is produced, a fifth phase may set in. Butyric acid-producing organisms cause the breakdown of residual carbohydrate and lactic acid. Proteolysis and deamination of amino acids, with the formation of higher fatty acids and ammonia, or even decarboxylation to amines may also ensue.

Butyric Acid in Silage

It is of vital importance in silage-making to prevent the fifth phase occurring. But as Barnett points out, while lactic acid production is commonly regarded as essential, the literature on this point, and on the correct conditions for its formation is both scattered and empirical. Good silage is regarded as having a low pH, high lactic acid and low butyric acid content. Acetic acid is looked upon as a more or less harmless product present to a greater or lesser extent. Barnett and Duncan[5] showed, however, that acetic acid can be present in good silage in considerable amounts. They also found that a low pH is by no means indicative of freedom from butyric acid, nor is a high pH necessarily indicative of a badly-made silage. They demonstrated the presence of appreciable lactic acid and residual carbohydrate in silages with high pH values.

The poor fermentation that is associated with high levels of butyric acid is more likely to be caused by side effects produced in the ensiled mass by Clostridia organisms. In well-made silage the activity of these organisms is minimal and their effects negligible, but where present in large numbers they cause extensive protein breakdown to amides, amines and ammonia. Such silage is often unpalatable to stock and this could be due to the presence of simple nitrogenous compounds rather than to butyric acid. Barnett[4] has demonstrated the palatability of silage rich in butyric acid, and it is worth recalling that butyric acid is a normal product of ruminal digestion. It is, however, desirable to have silage of low butyric acid content, for such silage is much more pleasant to handle and high intakes of butyric and acetic acids could prove excessively ketogenic and so impair animal health and productivity.

New techniques for controlling the silage fermentation process are intended either to stimulate lactic acid production, or to sterilize the crop to a greater or lesser degree and to prevent undesirable fermentations. In recent years, two types of techniques have been extensively studied, firstly, partial sterilization, secondly, physical methods that aim at concentrating or making the carbohydrates of the crop more readily available.

Use of Sodium Metabisulphite

Sodium metabisulphite was proposed as a silage conditioner by Cowan, Bratzler, and Swift.[8,9] In preliminary observations they ensiled a variety of grasses and clovers and added sodium metabisulphite in solution, at the rate of 8 lb per 2,000 lb of grass. They produced excellent silages that were very palatable to sheep and possessed a "clean acid odour and green colour". Further studies were made under farm conditions, where sodium metabisulphite was compared with molasses and controls. Dry matter losses were considerably lower in the sodium metabisulphite (M.B.S.) treated silages than in the untreated and molassed silages. Digestibility trial results with sheep implied that M.B.S. silage was superior to untreated silage in digestible dry matter and T.D.N. content. Carotene preservation was better and there was a reduced loss of fermentable sugar in the M.B.S. silage. The general trend of the results indicated that not only were more of the nutrients of the original grass retained by the use of M.B.S., but this additional retention involved the more digestible parts of the feeds. These authors claimed the superiority of M.B.S. silages for the following reasons: (1) reduced nutrient losses, (2) improved composition of the product, (3) better colour and smell, (4) more complete digestibility, (5) increased palatability.

Alderman and co-workers[1] studied the fermentation process in M.B.S. silage by analysing a series of samples from farms where this method of ensilage had been used. They found that lactic, acetic and butyric acid contents were only about half those for silages made by

other methods. These results suggested that M.B.S. partially inhibited acid production. All samples had a pleasant odour which was attributed to the very low levels of butyric acid present. Two-thirds of the samples analysed contained no detectable butyric acid. Proteolysis was of the same order as in other silages, but only to the amino-acid stage and there was little evidence of degradation to amines or ammonia. Reducing sugars tended to be high in M.B.S. silages, again indicating a restricted fermentation. Consideration of pH levels, which were rather higher than normal for good silage, implied that the action of M.B.S. was a bacteriostatic effect of the HSO^{-}_{3} ion and not of the H^{+} ion as in conventional silages.

CONFLICTING RESULTS FROM OTHER WORKERS

Limited supporting data were obtained by Archibold and Kumeski[3] who showed that volatile base contents were significantly lower in silages made with sulphur dioxide or M.B.S. Butyric acid contents were lower, whilst lactic acid, carotene and sugar levels were higher. They considered that if M.B.S. were used for ensilage, a high moisture content need not be a deterrent to the production of good silage. Gordon *et al.*[12] examined the effects of adding 9 lb of M.B.S. per 2,000 lb of crop to immature mixed legume and cocksfoot silage after wilting, and compared the M.B.S. silage with silage made from the same wilted material without any additive. Both silages were of good appearance and aroma, had a low pH and low ammoniacal nitrogen content. The M.B.S. silage contained more carotene. Storage losses were about equal at 10·0 per cent of the dry matter for both treated and untreated silages, but the M.B.S. treated silage seemed to be more palatable since voluntary consumption was 5·3 per cent higher than of the untreated silage. Gordon and co-workers[13] also ensiled unwilted legume cocksfoot mixture with and without the addition of 9 lb of M.B.S. per 2,000 lb of crop. Dry matter losses were 25·6 per cent and 19·6 per cent for the untreated and treated silage respectively. The latter was also more palatable and slightly more digestible. It was concluded that M.B.S. improved the preservation of silage made from unwilted herbage compared with no treatment, but M.B.S. was not as effective as proper wilting had been in the earlier experiments.

Other American studies have not shown any advantage from the use of M.B.S. Kennedy and Allred[15] concluded that M.B.S. reduced dry matter losses by only 3–5 per cent and was uneconomical to use as a silage preservative. In later trials Allred *et al.*[2] compared untreated silage and silage made with the addition of M.B.S. (9 lb/2,000 lb of crop), brewers grains (100 lb/2,000 lb of crop) and molasses (70 lb/2,000 lb of crop). Good silage was obtained from all, and dry matter losses were very similar in all treatments. There was no indication that M.B.S. reduced total or fermentation losses. There was no significant difference in digestibility between any of the silages, but in one year M.B.S. silage

was less palatable than the others and inferior in producing liveweight gains. The M.B.S. produced a better smelling product, but unfortunately no analyses were conducted for butyric acid or volatile bases in these studies. The herbage used (15·6 per cent crude protein and 27·7 per cent crude fibre in the dry matter) was typical of what might be ensiled in Britain, usually in the long state, and it is worth noting that the herbage was chopped prior to ensiling.

The initial promise of American studies on the value of M.B.S. prompted a series of investigations throughout Britain. Some fundamental studies were recently reported by MacPherson, Wylam and Ramstad,[16] who prepared grass silage in sealed bottles after treating the herbage with an inoculum of lactobacilli or with M.B.S. at the rate of 0·2g per 50g of grass, or with a combination of lactobacilli and M.B.S. Analytical data showed that M.B.S. had a bacteriostatic effect and permitted little bacterial fermentation. Considerable protein and carbohydrate hydrolysis occurred but without loss of the resultant amino acids and sugars. The latter were partly formed from cell wall polysaccharides and accumulated as reducing sugars to the extent that the sugar content of the silage was higher than that of the fresh grass. The authors emphasized that for consistently good results on a large scale, there must be adequate and thorough mixing of M.B.S. with the crop.

Compatibility of M.B.S. and Wilting Treatments

A comprehensive series of trials was conducted by Murdoch *et al.*[20, 22] The first of these papers reports comparisons of chemical composition and nutrient losses of silages made with and without the addition of M.B.S. In some instances the crop was also wilted and treated with M.B.S. With one exception, volatile fatty acid production was reduced because less butyric acid was formed. The M.B.S. silages had a more pleasant odour. Because there was less protein breakdown the results supported the American view that M.B.S. acts by inhibiting volatile fatty acid and volatile base production. Further, it was found that lower levels of M.B.S. (4–9 lb per 2,240 lb of crop) had little effect on lactic acid formation which was decreased at higher levels (12–16 lb per 2,240 lb of crop). The results suggested that M.B.S. might be of considerable value in ensiling protein-rich crops, but the best results were obtained with herbage that was chopped or wilted, and treated with M.B.S. This conclusion should be compared with the recommendations from Cowan *et al.*,[8, 9] that M.B.S. should not be used on wilted herbage so that oxidative change of the M.B.S. to non-bacteriostatic sulphate is avoided. Yet as Murdoch *et al.*[20] stated, provided consolidation of the crop is adequate, the two treatments are not incompatible.

The other trials of Murdoch and Holdsworth[22] compared M.B.S., molasses and wilting. In the first trial, pre-wilting was more effective than additives alone, while the combination of pre-wilting and M.B.S

was even more effective and reduced dry matter losses by about 10 per cent. This, of course, did not account for wilting losses in the field. M.B.S. again was found to reduce volatile acids and bases, particularly when combined with wilting, indicating that it acts as a bacteriostatic agent. In a second trial a wilting treatment was not included, and dry matter losses which were high throughout were not effectively reduced either by M.B.S. or molasses, but both treatments equally reduced volatile acid and base production. The third trial in this series merely compared M.B.S. with untreated silage, and further confirmed reduced butyric acid formation and reduced protein breakdown (measured by valeric acid content) in the M.B.S. silage.

Murdoch and Holdsworth[22] considered this second series of trials gave better results because a mechanical device was used for mixing M.B.S. with the herbage, compared with hand application in the first series. This stresses the need for adequate mixing of the M.B.S. with the crop, a matter of some difficulty with long material. Because molasses and M.B.S. were found to be equally effective in reducing volatile acid and base formation, the choice between them will depend upon relative costs and ease and efficiency of application. It is interesting to note again that M.B.S. was inferior to wilting but that wilting combined with M.B.S. was the most effective method of producing desirable fermentations.

Brown and Smyth[7] also compared molassed with M.B.S. silage and obtained slightly better conservation with the latter, but both were equally effective in reducing volatile acid and base formation. Again it was found that difficulty of application precluded the general use of M.B.S. Unfortunately these workers used mature material (10·5 per cent of crude protein and 29·4 per cent of crude fibre in the dry matter), which can be fairly easily ensiled without additives, and which shows after ensiling no more loss than molassed silage (Brown and Heaney).[6]

Calcium Formate and Sodium Nitrite

Although a number of other additives have been tried in recent years, only one appears to have been introduced commercially. This consists of a mixture of calcium formate and sodium nitrite. Moore[17] has reported the results of two years' experiments in which such a mixture was compared against controls. In the first year the treated silage was slightly lower in ammonia and butyric acid contents, but slightly richer in lactic acid than the control. Rather better dry matter preservation was also obtained. In the second year no differences were observed. These results do not permit a definite conclusion about the use of calcium formate and sodium nitrite, but Moore considered that such a mixture was unlikely to be of very much use with wilted crops. A similar trial reported by Murdoch[21] also gave inconclusive results.

Wilting, Chopping and Laceration

Poor fermentations are frequently observed in silages of high water content. Water in the crop is important not only because of its effect on fermentation, but because of the increased seepage losses and additional power requirements for harvesting. A good deal of attention has been paid to physical processes and their effects in ensiling high moisture grass. These include chopping, lacerating and wilting of the crop prior to ensiling. Some advantageous effects of wilting have already been noted.

MOISTURE CONTENT

Barnett[4] showed that the presence of water is not necessarily a deterrent to the production of good silage. Craseman and Heinzl,[10] however, demonstrated fairly clearly that the drier the herbage when ensiled the more satisfactory the lactic acid production, and found that under very wet conditions butyric acid was produced in spite of acid addition. They suggested that ensilage was more reliable when the moisture content is low, irrespective of the use of additives, and that for good silage-making, wilting plus acidification, by means of mineral acid, should be used. Holdsworth[14] reported similar results from silages ranging from 19·8–39·6 per cent of dry matter. Lactic acid formation increased as dry matter increased, whilst total volatile acids and bases decreased. Nutrient losses, particularly of soluble carbohydrates, due to fermentation were also lower after wilting.

NUTRITIONAL VALUE

Nash[23] considered that there was little difference in nutritional value between molassed, unchopped and chopped, untreated silage from the same crop, but stated that chopping permitted ensiling without molasses. He also found that laceration produced a more uniform silage, but unfortunately no analytical data were obtained. Woodward and Shepherd[25] had earlier noted that chopping and wilting to 30 per cent dry matter improved silage quality. In this connection, it is interesting to note De Man's[11] observation that while crushing produced a better silage, the pH was not always lowered to 4·2 or below.

QUALITY COMPARISONS

Experiments specifically designed to compare the quality of silage from lacerated, chopped and unchopped herbage, either with or without wilting were conducted by Murdoch *et al.*[19] They also studied the value of molasses on chopped silage. The chopped herbage was in pieces 2–4 in. long, while laceration produced a more drastic effect and almost shredded the grass. The results showed that chopped and lacerated silages had lower pH values than unchopped silages, but that

there was little difference between the wilted and unchopped silages. Wilting unchopped material increased lactic acid formation but chopping wilted material produced the greatest increase. Lacerating wilted material was not so effective in encouraging lactic acid production. The lacerated silages, however, were generally richer in acetic acid than the chopped silages, and chopping combined with wilting lowered acetic acid considerably.

All treatments were effective in reducing butyric acid formation, but again wilting was superior to chopping or lacerating. Chopping and applying molasses was also very effective. In these trials butyric acid in the silage was generally correlated with volatile base content, but chopping just about halved protein breakdown and was more effective than laceration in this respect. Proteolysis was considerably reduced by wilting although in one instance chopping or lacerating and wilting increased volatile base formation. Molasses used with chopping also substantially lowered volatile base formation.

The results, therefore, confirmed those of other workers that chopping or lacerating improves silage quality—such silages being consistently better in appearance and smell than unchopped silage. Occasionally, high levels of butyric acid and volatile bases are found in chopped silages and these may be caused by over-consolidation. The observation that wilting resulted in a lower overall production of acids and less proteolysis confirms previous results, produced by Murdoch, Balch, Foot and Rowland,[18] that wilting reduces the total losses involved in silage-making. Nash[24] has recently reported comparisons of quality, losses and digestibility of partially wilted and unwilted silages. The wilted grass showed lower nutrient losses, but there was little difference in fermentation quality between the wilted and unwilted silages. Digestibility of the dry matter was not affected by wilting.

Conclusions

The majority of the experiments have shown that M.B.S. is effective in producing a very desirable type of fermentation, provided that it can be intimately mixed with the crop. There appears to be little advantage in using M.B.S. to reduce nutrient losses and its use will depend entirely on its cost and ease of application compared with other additives. From the limited data available it seems that there is no advantage in the use of a mixture of calcium formate and sodium nitrite. For practical silage-making none of the additives is as efficient as the physical agencies of chopping, lacerating or wilting in reducing losses, and securing a better fermentation as judged by minimal butyric acid and volatile base formation. Wilting is the best treatment of all, especially if combined with chopping. The use of wilting will depend to some extent on the climate in the area in which the silage is being made. In view of the excellent experimental results produced by this treatment numerous large-scale studies of the efficiency of wilting in varying climates would be desirable.

Fermentation quality of silage is likely to assume greater importance as the amount of silage made and fed increases. This is particularly true for self-feed silage units, where the object must be to encourage appetite for silage. There is evidence that appetite (measured as dry matter intake), for high moisture silage is lower than for wilted silage, and the appetite depressant might relate to the type of fermentation generally found in wet material, rather than to moisture as such. It is also recognized that the digestibility of the herbage partly controls appetite, but highly digestible leafy grass is usually low in dry matter. Wilting and chopping or lacerating, therefore, must develop as normal practices in practical silage-making on the farm, because young, highly nutritious herbage is vital for successful self-feeding. The increased cost of wilting and chopping or lacerating such material, compared with the cost of buckraking longer and more mature herbage into a pit or walled clamp, must be accepted as an integral part of an efficient ensilage programme. This increased cost, however, will be justified and amply repaid by the enhanced nutritive value of well-made, leafy silage.

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Advisory Methods

(*A paper read to the County Agricultural Officers' Conference, April* 1960)

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I SUPPOSE that one of the earliest and saddest lessons we have all had to learn in our careers as advisers is that the advisory method which is responsible for this year's success is as likely as not to be the cause of next year's flop.

How often have we adopted an advisory method which for a time promised to be exactly what we needed to make our work more effective —only to find that when we tried to transplant it into a different environment, the results were just as disappointing as they had originally been encouraging. Just to make the whole thing more annoying, we could never find out why it failed—in fact if we are honest with ourselves, we never really knew why it succeeded in the first place.

The very natural reaction of most of us to this sort of experience is to play for safety, to ring the changes on the advisory methods available and not to rely too much on any single one to get a story across, in case it lets us down.

The purpose of my paper is to discuss whether this state of affairs is inevitable, or if some rational approach can be devised which will serve us better than the hit-and-miss lines of thinking which we have used in the past. I can approach my part in this appraisal from one of two angles.

The first is the *scientific approach*. With this approach I shall be looking for factual information, resulting from carefully-designed trials, which will indicate the merits of one advisory method relative to others over a whole range of different conditions. As a technical service composed of trained scientists there can be little doubt that this is the trail we should follow.

However, it seems that most of the published work originates in the U.S.A. and I do not know enough about their conditions to be able to judge the validity of some of the conclusions which they draw. It is quite certain that the basic principles governing the communication of ideas hold true the world over, but their application must be governed by the social and economic peculiarities of the community to which they are directed.

So little work has been done in our own conditions that, again, I should feel very vulnerable if I tried to base my remarks on local results. In any case, some members of my audience have far more knowledge than I have of these particular projects.

The alternative approach—in what I judge to be the absence of scientific evidence—is to see if *reason* can be made to substitute for hard facts—to see if we can devise an argument which will stand the tests of logic.

Objectives of the Service

Before we try to assess the merits of the methods we use, we must be very clear about what we want these methods to do for us—which is just another way of asking what we expect an advisory service to achieve. I have met individuals who feel that it was not very good psychology to include the word Advisory in our title. They argue that there is something rather condescending about the word—that people don't like being "advised"—that they prefer to be "informed" and left at liberty to use that information as they wish.

Yet if we think about what we are trying to achieve, it is very difficult to find a better word to describe our approach, for surely the word *advise* epitomizes what we set out to do. It is not sufficient for us merely to inform—to provide our client with several alternative solutions to his problem. It is the very essence of our service that we go a stage further and advise him which of those alternatives is best for his circumstances. Of course, the final decision and responsibility must remain with our client, but this should not be allowed to absolve us from an equally great responsibility of ensuring that our client knows what we think he should do—what specific action he should take. In the long run, we can only judge the success or failure of our work by the amount of action we induce, not by the amount of information we dispense.

These statements may strike you as being so self-evident as not to be worth making, but nevertheless, I do feel that, if we are to make a reasoned study of the methods we use, we must first get our objectives clear. We should not forget, either, that we have both immediate and indirect objectives.

Mostly, we are dominated by the short-term objective of getting somebody out of a particular mess, but there are also occasions on which our objectives are more subtle—when we are aiming to *change peoples' attitudes* to agricultural development, to productivity, to the very process

of change itself, in the hope that thereby our immediate objectives will be more easily achieved and more widely applied. When discussing advisory methods we should try to get our minds clear on whether we are aiming at solving immediate problems or at changing attitudes—they need different lines of approach. Ultimately, however, they all aim at inducing people to change their habits, to adopt new methods, or to do new jobs.

The Psychologist's Model

If you have read the literature you will not have gone very far before coming into contact with the psychologist's model—a theoretical concept of the mental processes through which a man goes before he accepts a new idea. We are told that there are several well-defined stages—the number varies slightly from one authority to another, but the broad theory seems to make sense and runs roughly along these lines:

AWARENESS

A new idea has been developed, a new product manufactured, a new technique perfected. We learn of its existence—nothing more—we have no detailed knowledge of it nor do we know its intrinsic qualities.

INTEREST

If we are to proceed to this stage we must take action—seek information, by reading, listening or asking questions.

EVALUATION

Having assembled such information as is available, we now try to assess the merits of the new idea relative to our own circumstances—would it be of any use to us; would it make life easier, more exciting, more profitable?

TRIAL

As a result of this evaluation and if the answers are satisfactory, we try out the idea, physically, in our own circumstances.

ADOPTION

If the previous stage has been satisfactory we put the idea into operation, intact or modified, and continue with it until something better comes along.

These we are told, are the stages through which we all go before we adopt new ideas and they apply with equal force to the small decisions and the big ones—whether we are involved in changing our brand of tooth paste or in taking a wife.

If I may refer back to my earlier remarks for a moment, this concept emphasizes very well what I was saying about the service's objectives—if we were simply an information service, we might feel we were

involved only in the first two stages, whereas, as an advisory service, we are clearly implicated all along the line.

Speed of Adoption

If this model is acceptable, it is quite obvious that the speed with which these five mental processes are completed is going to vary greatly between one set of circumstances and another, because of the influence of the following factors:

EFFICIENCY OF COMMUNICATION

The first important factor will be the clarity with which the original message is received. If we try to make an analogy between our own problems of communication and those of a radio system we might break the process into three stages.

The Transmitter

If we reduce this to personal terms we must, I suppose, admit that some of us are just not as powerful transmitters as others—we just haven't got the kilowatts—we are not as efficient as generators of messages—not as good at collecting information, assembling our facts and drawing useful conclusions from them.

Again, not all of us are equally good at encoding our messages—at expressing ourselves in either the written or verbal form, or at knowing in which direction to beam our advice.

The Medium

We rarely have exclusive rights to any particular wavelength. In most cases other transmitters are at work and they may not always be telling the same story, or giving the facts the same interpretation.

The Receiver

We spend most of our lives thinking about the man at the receiving end of our messages, but do we always give full regard to the fact that our public is just about an accurate cross-section of the whole adult population, with all the inherent variations of age, experience, education, habits and prejudices? How often do we really know what our customers require of us—what sort of advice they need? How often do we try to find out? Could we find out, even if we tried, with such a mixed bag of clients?

Of course, it may not always be necessary for us to directly influence everybody. The literature is full of references to *innovators* and *community leaders*, with assurances that if we can locate these elusive customers they will do our work for us! I wonder if it is as simple as all that. What has always struck me is not the speed with which farmers learn from one another, but rather the very reverse. A recent N.I.R.D. survey on milking machine cleansing methods indicates that, on this

subject at least, farmers learn from "over the hedge" much more slowly than by other media. It is, clearly, something we need to know a great deal more about before dogmatizing.

NATURE OF THE MESSAGE

Acceptability. It is reasonable to expect that new ideas which lead logically on from existing practice and conform with present attitudes of mind are the most likely to be acceptable. Even really revolutionary ideas can sometimes be presented so that they seem to evolve from existing practice and as such are the more acceptable.

Nature of change involved. This probably has more effect on speed of acceptance than any other single factor. The forces at work are not easy to define, but it would seem that types of change fall roughly into three categories:

> *Materials.* When only changes of materials are involved, acceptance is quick. New varieties, new herbicides, new machines come in this category.
>
> *Methods.* These do not involve radical changes of farming system, but rather the techniques by which the system is operated—changing strip grazing to rotational grazing or vice versa—substituting silage-making for hay-making. The changes are achieved much more slowly and with much greater effort.
>
> *Changes of System.* An example might be changing over from arable farming to cow-keeping. Changes of this sort are so difficult as to be well-nigh impossible to achieve.

I know that any grouping of this sort is bound to be rough, but when we have to decide which advisory methods we should use it may be helpful to employ such a grouping as a means of assessing the difficulty of the task we are to undertake.

Methods Available

Against this background we can now look at the advisory methods available to us. I propose to group them in the conventional manner into (1) Mass, (2) Group and (3) Individual.

I think we all know what we mean by these terms, although the line between Mass and Group is rather indefinite in some people's minds. To me a group is a body of people who have some *closely defined community of interest*. A collection of people does not constitute a group just because its members happen to live close to one another or because they happen to have assembled in a certain place. My definition of a group hangs on people's vital interests rather than on their propinquity.

I would now like to refer to the psychologist's model which I mentioned earlier and to superimpose upon this the three methods we are able to use.

	Mass	Group	Individual
Awareness	x		
Interest	x	x	x
Evaluation		x	x
Trial		x	x
Adoption			x

From this we might argue that when our objective is first to make people aware of new developments, the mass methods are ideal—indeed, are often all that is needed. When this initial stage is past, mass methods are still valuable for satisfying people's further interest. Group and individual methods can, of course, also be used to good advantage.

When a man reaches the stage of trying to evaluate a new idea, it might be argued that mass methods cease to be of use, for they cannot take account of his personal conditions. The individual approach is usually the ideal one at this stage, but groups can be almost as valuable —especially if those comprising the group really have common interests and are, thereby, able to help one another sort out the pros and cons instead of having to rely on a single adviser as with the individual contact.

The process of trial seems to be a matter for the individual, but again we should not ignore the possibility of a group of people going through this stage together and learning more as a result.

This all seems to work out as a nice tidy theory! How can it help us decide, when we have a message to communicate, which method or methods to adopt? Where do we start?

Personal Contact

We know most about the work of our D.A.Os., so perhaps we can start from there. They are our main point of personal contact with farmers. The records we have available show that if a D.A.O. has 700 farms exceeding 15 acres, and if he stays in his district a reasonable length of time—6 or 7 years—he will make personal contact with about half of his farmers—that is about 350. This is roughly the number of advisory visits he will pay in a year, so he averages one visit per contact per year. Of course, the pattern is uneven about this average—in the east, for instance, there seems to be a very direct relationship between number of visits per contact and farm size.

If we think for a moment of this average of one visit per year, we must surely conclude that a D.A.O. is hard put to it to keep in individual contact with his existing clientele and even so, we can hardly claim that he can be a major influence on farming policy even on the farms he visits, if he is only able to pay one visit a year. I am well aware that, on occasions, it is possible in the course of a couple of visits to put the farming of a considerable unit on a sound basis for years to come, but these instances are exceptional. Our records show that most of our advisory visits are still related to spot problems, and it is with this in mind that I have suggested that our present contact with farmers is more tenuous than some of us care to admit.

The urgent question is, can we use the other advisory methods to *supplement* individual visits? In the past, whilst our Service was developing, we have been happy to use Mass and Group methods to stimulate interest in new developments in the knowledge that we could

satisfy demands which arose by individual visits. Many of our colleagues warned us that, if we persisted in the use of Mass and Group techniques, we should end up in a snowball—and the model which I have used certainly seems to support this contention.

In the Eastern Region (and probably in others as well) we have now reached the stage at which our time is very fully occupied with existing commitments and yet we know that demands for our services are bound to increase as our Service becomes more firmly established, as farming becomes technically more exacting, as profit margins shrink, as farmers get better and the less efficient ones drop out.

What to do about Mass and Group Methods

If we are to find permanent relief from snowballs, we must approach our work more systematically and use the methods available as complementary one to another.

INDIVIDUAL VISITS

As well as solving the immediate problems of an individual, can we not take full advantage of these unique opportunities to *influence his attitudes* towards our Service and to receiving advice? Can we use individual contacts to condition farmers to accepting their advice—at the *Trial* and *Adoption* stages—by Mass and Group methods?

There is a suggestion that this may be possible from some of the counties in our region. For example, the Isle of Ely has an excellent liaison with the local Press, and in talking to D.A.Os. in that county, I find that, consciously or otherwise, they have, in the course of their individual contacts, been preparing farmers to accept detailed advice through the press columns, and at the same time teaching them how to use this sort of information with discretion. If this is possible, it is a most interesting development, for it means that some of the burden now carried by D.A.Os. can be re-distributed. County Agricultural Officers and Regional specialists writing or addressing meetings in such a "conditioned" society have half their battles won before they start—the willing ears are turned for their words of wisdom.

MATCH METHOD AND MESSAGE

We should use mass methods with discretion and with more purpose than in the past. They are most effective for getting over simple messages. I have suggested that changes of materials or simple changes of techniques prove to be the most easily acceptable. Can we not, therefore, concentrate on mass methods for getting across this type of change?

The Cambridge work on cereal varieties, wheat bulb fly and slug control clearly show that demands for individual advice can be greatly reduced—or completely stopped—by the issue of a carefully-prepared leaflet, issued wholesale to the farming community.

STIMULATE AND SATISFY AT SAME TIME

It is clear, therefore, that on occasions we can stimulate interest in a new development and also satisfy it by means other than individual visits. How far is this confined to simple messages? Undoubtedly it is so in the case of mass media, but much more complex subjects can be dealt with in groups. I might be forgiven for quoting from my own experiences with the Farmhouse meetings which we held in Cornwall on Farm Management—a complex subject, I think you will agree.

When Mr. Arthur Jones first started castigating us all for neglecting the £ *s. d.* of farming, we took stock of our position in Cornwall and it seemed to us that if, by careful preparation, we were able to offer a sound farm management advisory service, then the demand for it in that area of low incomes might easily overwhelm us—especially if we gave the service plenty of publicity and stimulated interest by means of press articles and large conferences.

So we looked around for a method which would supplement our individual advice, not only telling farmers what we had to offer, but also giving them enough information to enable them to solve the simplest of their own problems. We selected our groups carefully for their community of interests and we taught them basic farm management principles—how to read a farm account, the relative importance of volume of business, fixed versus variable costs, budgeting for simple changes. One of my most rewarding days was when I went to Helston market and came across a gathering of half-a-dozen local farmers scribbling on the backs of envelopes, budgeting out a change which one had suggested to his farming system.

How Should our Approach be Altered?

Does the foregoing mean that we should re-think our approach to the three methods available to us?

Individual Visits: As well as answering specific questions should we not also use these opportunities of building up farmers' confidence in Mass and Group advice?

Mass Methods: Should we not be far more selective in the messages we try to transmit in this way, confining them to simple changes and only using this method to *stimulate* interest in more complex things when something really new and important comes along?

Groups: It is in the development of these that I see our greatest hope, but *we must be more selective*. The day of the general meeting has gone. When selecting our audiences, we should bear in mind that if they are selected for real community of interests, then far from ruling out individual idiosyncrasies, differences of age, background, education, experience, we shall *capitalize* on them. Groups are essentially a joint exercise in which the progressive can be used to help along the others; in which the experience of age can be used to temper the enthusiasm of youth.

We need to review our attitudes to the three main advisory methods available to us and to use each one to supplement the other in an orderly manner. Exactly how this can be started in the absence of any fund of factual information is not easy to say. I have given you some of my own opinions, but because they are no more than opinions, I think I can best summarize my thoughts in the form of questions rather than dogmatic statements.

Do we do enough to assess the need and applicability of new information before we start to retail it?

When we have a message to communicate, do we ask ourselves what we hope to achieve—a definite action, or a change of attitude?

Do we think enough about the variable nature of the audience for which our message is intended?

Must Mass and Group methods always produce snowballs? Is it not possible that as our service develops we may reverse some of the present trends—and instead of using Mass and Group methods to stimulate demands for individual advice, use individual contacts to condition farmers to accept advice more readily by Mass and Group methods?

Are we selective enough in forming our groups—have we really appreciated the great possibilities of this method of giving advice?

I should like to feel that as a result of our discussions here today we resolved to get more information about the use of advisory methods and that we charged some of our colleagues who are already interested in this subject with a task of making a critical review of such knowledge as is available here and in other countries. A study of their research methods and the way they put their findings into operation may well form a basis on which we could build our own programme of research into this fascinating subject.

An Experiment in Communication

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WHEN thinking about the approach to adopt in describing this experiment in communication, the first line of a well-known Yorkshire dialect rhyme came to mind: "Hear all, see all, say nowt." Many advisory activities allow audiences to "hear all" that we have to say, and many others allow the audiences to "see all" that we have to show, but unlike the saying, are we continually striving to *prevent* our audiences from saying "nowt"?

Perhaps we have tried too long to satisfy interest, whereas we should have devoted more attention to its stimulation. Perhaps advisers have sat farmers on chairs and lectured to them for too long. Attendances at the formal lecture are more difficult to maintain, and this method of "hearing all" was patently due for overhaul. Similarly, the visual method of communication via film and slide is now rather dated, and replacement by other methods should be considered.

Field demonstrations, whether in winter or in summer, have been one of the main planks of our advisory activities for many years, but all three methods, the lecture, the film and the demonstration have similar failings. They tend to be impersonal in their contact; an audience may be allowed to "hear all" or "see all" but none of these methods provokes much contribution from the spectator by either comment or questions. The successful adviser knows the importance of personal confidence in getting his story across to the individual, but this type of relationship is not greatly fostered by any of the three approaches mentioned above.

Exchange of Ideas

The logical step was to do what many advisers, including the writer, have done; to develop forms of communication that allow for a much greater degree of personal consultation and two-way traffic in terms of ideas. These take the form of smaller groups operating in a more informal atmosphere and discussing in much greater detail the problems involved in any particular subject. This type of approach has achieved a great deal in recent years, and probably has a great deal more to offer. The main criticism to be levelled against it is that it is necessarily restricted to very small groups.

The ideal would seem to be to combine the personal effectiveness of the individual approach with the mass coverage one gets by use of mass media. It was thinking along these lines that prompted the idea of a combination of the visual and oral approach.

Disappointing experiences with educational exhibits at one-day shows, some conventional and some unconventional in their design, had

lead to the conclusion that people came seeking entertainment rather than education. If the exhibits in themselves were worth looking at and had something of value to convey to the farming community, one could conclude that the time, and the place could be blamed for the lack of response. These thoughts eventually led to the idea of an indoor exhibition, held during the winter months and with the support of a vigorous local agricultural discussion society, the Selby and District Agricultural Club.

The outcome was an interesting experiment in communication entitled "Practice With Science," which took place on the evening of 17 November, 1959. The exhibition design was based on the maximum use of farm equipment and the minimum use of written background material. The subjects chosen were indoor sprouting of potatoes, spring mechanization of the sugar beet crop, milking parlours, and poultry. An exhibit of general interest formed a centrepiece, based on a display of antique implements and equipment.

Farmer Demonstrators

The exhibits were staffed with both technical officers and farmers practising the particular technique being demonstrated. These farmers were drawn from the local Advisory Committee and the Selby Agricultural Club wherever possible. The practical nature of the exhibits and the offering of a practical and a technical opinion for each exhibit, proved to have great appeal to the farming community.

The exhibition struck quite a different note compared with an exhibit at a summer agricultural show. For one thing, the onlooker had no written message to interpret. The practicalities of the exhibits ensured a basis of common ground and encouraged participation by the farmer visitors, with the result that the demands on demonstrators' time were particularly heavy. Another advantage was that the expense of staging this event was not high and consisted mainly of the hire of the hall, the cost of publicity and transport; much of the latter being provided free by members of the Selby Agricultural Club. All the farm equipment was provided free of charge and no expenditure was incurred on signwriting.

The exhibit "Indoor Sprouting of Potatoes" demonstrated four different types of lighting arrangements. Some 300 trays were used to demonstrate the method of stacking and the best layout of a building. Sufficient boxes were used to construct three passageways. In the first of these, two 5-ft tubes with a choke unit attached to the tube support were demonstrated, these units being hung from an overhead metal rod which traversed the length of the passageway. The second passage was used to demonstrate two 5-ft tubes with the choke unit fastened on the roof timbers; the method of supporting the light unit was a "T"-piece junction attached to the top of the light unit support. The ends of the "T" rested on the top trays, leaving each light unit free and independent of any overhead rod or cable. The third passageway was used to demon-

strate the difference in light intensity between two 4-ft tubes and a single 8-ft tube, the advantages of the single 8-ft being clearly shown.

Practical Information

The exhibit was connected up to the main electricity supply in the hall which allowed us to illuminate the exhibit exactly as it would have been in practice. The time of year was not suitable for showing the ideal sprout, but because of the importance of this aspect, a tray of seed potatoes was specially treated with heat and light for six weeks before the exhibition, and we had a very satisfactory display of sturdy green sprouts with which to make our point. Inquiries from farmers were concerned mainly with the cost of installations, the effect on yield, and whether all varieties required the same treatment.

The milking parlour exhibit was based on large-scale working models supplied by the A.L.S. These demonstrated four different types of milking parlour, a four-stall two-unit tandem, a four-stall two-unit chute tandem, a three-stall, three-unit tandem, and a four-stall two-unit-abreast parlour. Inquiries on this exhibit were related to cost, labour economies, feeding methods, and milk yields.

The poultry exhibit consisted of a wire floor unit on which were exhibited different watering and feeding utensils, some of the latter showing modifications made on the farm to improve their flexibility. There was also a unit of roll-away nest boxes. The demonstrators placed emphasis on egg quality, by keeping eggs in a clean condition, thereby obviating washing, with its attendant risks of deterioration and cracking. Most of the inquiries on this exhibit were devoted to increased stocking rates and disease factors, and of course the constant inquiry on capital cost.

The sugar beet exhibit demonstrated down-the-row thinning and precision drilling, the former being a working model kindly provided by the N.I.A.E. This highly effective model had steel pegs set in putty to simulate the beet plants in the soil. It clearly demonstrated the points at which plants were struck out of the row and the effect on plant population of different-sized thinner heads, which could be fitted to the model. Inquiries here centred around plant populations, seed rates, types of seed, and comparisons with hand work. Cost did not enter into the discussions so much on this exhibit, since sugar beet growers generally seemed prepared to purchase new equipment if they could be convinced of its effectiveness.

The value of both technical and practical viewpoints on each exhibit is shown by some of the talking points mentioned above. The first-hand experiences of the farmer demonstrators were invaluable in dealing with inquirers whose main concern was to find out the practical usefulness of the new techniques being exhibited.

Satisfactory Response

Assessment of the attendance at an exhibition of this type is difficult because the farming public were coming and going throughout the three hours of the exhibition, but it was estimated that two hundred people passed through the hall during the evening. There may be advantages in staging such an exhibition as a full-day function. But this raises problems of duty rotas and additional voluntary helpers, and for our first excursion into this field we decided that an evening function would be adequate.

The general atmosphere was well expressed the following day in the local press which carried a headline "When the Farmyard came to Town", and continued: "The organizers must surely have been satisfied with the response obtained by the exhibition. The hall was filled with people from all sides of the agricultural industry and there was keen interest in the exhibits. Farmers and technical advisers staffed the displays to give explanations and advice. There was no lack of questions."

As a sequel, the event is to be repeated on a county scale in 1960. It seems likely that for a time at least this form of communication has much to offer in those fields of husbandry which lend themselves to exhibit form.

Little has been said about the display of antique implements and equipment. This was incorporated more as a gimmick than with any educational intent, but it served its purpose with outstanding success. The younger generation peered with disbelieving eyes, whilst the oldest visitors looked on with reminiscent smiles at this brief reminder of their childhood days. There was a small prize offered for the identification of a mystery object. The prize was not claimed until late in the evening, and then by a N.A.A.S. officer who hailed from Dorset. He recognized the object as a tool for holding in place heather or birch branches whilst they were made into brooms.

Regional Note

Plots on a Small Showground

J. D. LAURANCE

National Agricultural Advisory Service, Rutland

RUTLAND is fiercely proud of being England's smallest county. There are no large towns and farming is the main industry, the farms being large by national standards and well run. Liaison between farmers and the N.A.A.S. is close, and Rutland Agricultural Society warmly welcomed our suggestion of having a permanent Ministry site on the Showground.

Developing the Idea

The site lies between the main ring (a centre of attraction on show days) and the main road. Fencing was essential as the Showground is grazed during the "off" season. Fortunately, the A.L.S. were looking for sites for permanent fencing exhibits, and the happy result was that the N.A.A.S. area was enclosed by an A.L.S. exhibit showing six types of fencing and four types of gate, including a Kissing Gate giving access from the road. All the gates and fences are identified, and an explanatory leaflet is available in a simple dispenser. Farmers travelling past the site can inspect the fencing or the plots at any time and the interest shown in both has at times been almost embarrassing.

The Caravans and the Plots

Basic layout of the exhibit is simple, consisting of three of the Ministry's caravans forming a half moon with their backs towards the road. In front of the caravans are two plots each 15 × 30 ft, with a central gangway 20 ft wide.

A great deal of work and worry is avoided by using the caravans, which are more in keeping with a small one-day Show than a large marquee, and although they must be towed to the site, tent hiring costs are avoided. The exhibits are prepared elsewhere, transported in the caravans and assembled in a very short time. They can be used throughout the Region at markets and other events—a feature that has been most useful.

Of the three caravans, one accommodates the Bookstall, one is used by the N.A.A.S. to house an exhibit bearing on the main theme, and the third by another Ministry Branch (e.g., Pests or Safety & Wages).

The impact of the project has been considerable. A visible demonstration of the type we have been able to arrange seems to stick in farmers' minds longer than any amount of written or spoken material, and it is not confused, as on a farm walk, by a mass of extraneous detail. The results are obviously genuine (farmers are becoming very suspicious of fake material). This is only possible because there is complete control of the plots throughout the whole year.

Grassland Improvement

The soil is a deep red loam and had never been ploughed within living memory. The first exhibit on the site, in 1958, was on Grassland Improvement. The existing herbage was much as one would expect from a field which had for many years been grazed in the winter and spring and later mown for hay, and the soil was rather low in fertility. The north plot was dug in early January, the turf being put well down. A good seed bed was easily obtained and at Easter three grass seed mixtures consisting of timothy/meadow fescue, S.23/white clover and straight S.22 for early bite were sown. Germination in the dry April and May of 1958 was poor, but in due time the grasses came and the problem by the middle of July was to keep them in check. Fortunately, however, the plots looked magnificent on show day. On the following day the ryegrass plot lodged!

The south plot was not dug but was used to demonstrate Grassland Improvement without ploughing. It was divided into three. The first plot was allowed to run more or less wild and received no fertilizer or treatment of any sort, apart from some selective grazing. The central plot received lime and fertilizer and was mown to encourage the better grasses. The third plot was surface cultivated, receiving lime and fertilizer and a small quantity of white clover. This plot, like the central gangway and surrounding plots, received two sprayings of 2, 4-D which cleaned up the weed population. Some cow "pats" were imported to add realism!

The use of dalapon for twitch control was news in 1958 and the Caravan Exhibit was devised to illustrate some of its possibilities.

Potatoes

A comparison of planting dates using chitted and unchitted potatoes was the theme in 1959. 'Ulster Supreme' was used, as it was thought that this late maincrop variety would give the maximum effect. Rows of chitted and unchitted seed were planted on three different dates. The results were demonstrated at the show by lifting two plants at the end of each row. On the south plot a selection of newer second early and early main crop varieties were grown. Yields on both plots were extraordinarily good in spite of the dry weather. The Caravan Exhibit was devoted to sprouting seed potatoes under artificial and natural light.

"Sheep Keep Throughout the Year"

In the present season, a theme of "Sheep Keep Throughout the Year" was used. The south plot was put down to short leys, one being S.22/S.100 sown direct, and the other an Italian ryegrass/trefoil ley with some chicory added, undersown in a crop of S.172 winter oats. The winter oats were sown in October but had to be mown at the end of June in order to give the ley a chance, as the crop proved to be very heavy. On show day, sheep, borrowed from a local farmer, were penned on the plots—leaving about a yard of the ley visible in an untrampled state—to add interest and action to the exhibit. The sheep were 1959 lambs. In one pen they were shown with their lambs born in 1960, whilst in the other pen, were their sisters which had not been mated. This illustrated the advantages of breeding from lambs—a practice which may have a bearing on the future economics of sheep farming.

On the north plot a selection of root crops including three kinds of kale—marrowstem, thousandhead and Canson—were grown, together with mangolds and sugar beet. The remainder of this plot was devoted to a mixture of rape and turnips. The kales were sown at two different dates—21 March and 7 June—the early sowing being designed to demonstrate the different appearance of the three kales and the later sowing to demonstrate the same three varieties as they would look if sown at the normal time for sheep feed. As sheep were the theme this year, one caravan was devoted to exhibits on pregnancy toxaemia and the control of foot rot. The Bookstall was there as usual but the third caravan was replaced by a rabbit control exhibit. A scale model of the "Rutland" sheep dipping and handling layout was also on view.

Catching the Eye

As an eye-catching gimmick, raised banks containing the initials M.A.F.F. and a horse shoe (The Rutland County emblem) were prepared. In 1958, when grass was the theme of the exhibit, the letters and horse shoe were sown with S.22 Italian ryegrass and the surround with S.50 timothy. The latter was clipped tight while the letters and horse shoe were cut off at about 6 in. high, thus giving both a colour and texture contrast, which proved very effective. In the following year when potatoes were featured, the background used was damp peat and the symbols were picked out with the tubers of various potato varieties. In 1960, the symbols were picked out in various grades of wool, also against peat. The type of material used (e.g., "Red Craigs Royal" or "Greasy Dip-tinted Masham Ewe") was labelled. The aim has been to link these banks, which are really for decoration, with the theme of the exhibit and to avoid too much of a public park effect. They always provide a useful "talking point", however.

Has it been Worthwhile?

Public reaction has been most encouraging. Many farmers have commented that a simple live exhibit is of far greater value than a static one. Now that the Ministry plots have become an integral part of the show, farmers come to see them as a planned part of their visit. The site is always crowded and we feel that time spent on growing the plots is an excellent investment, and that more can be accomplished and more farmers reached than by any other means.

The plots can also be used later for demonstration. For instance, a small open day was organized in September 1959 when the final lifting of the chitted and unchitted 'Ulster Supreme' potatoes was made. The fencing exhibit is of course a silent ambassador for the A.L.S. throughout the year.

We do not consider ourselves obliged to grow crops on the permanent site. It could be used for an exhibit on poultry housing, a drainage exhibit or something similar. We have been fortunate enough to enjoy complete co-operation from Regional Specialists, all of whom have taken a great interest in the project.

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